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Investigating the potential economy wide impacts of energy efficiency improvements in Northern Ireland

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Disclaimer

The analysis in this report has been conducted by Kevin Connolly, Gioele Figus and Rebekah Tait at the Fraser of Allander Institute (FAI) at the University of Strathclyde. The FAI is a leading academic research centre focused on the Scottish economy.

The analysis and writing-up of the results was undertaken independently by the FAI. The FAI is committed to providing the highest quality analytical advice and analysis. We are therefore happy to respond to requests for technical advice and analysis. Any technical errors or omissions are those of the FAI.

Executive Summary

Northern Ireland has committed to achieving a Net Zero carbon economy by 2050, necessitating significant changes in energy supply and consumption. A pivotal focus of policy is the "do more with less" principle, emphasising enhancing energy efficiency in buildings, especially in the residential sector, which contributed to 12% of greenhouse gas emissions in 2021 (NAEI, 2023). Alongside environmental objectives, there is a goal of fostering a greener, more inclusive society by growing the low carbon and renewable energy economy (LCREEE). This report aims to analyse the economic and environmental ramifications of energy efficiency programs in Northern Ireland.

To achieve this, we employ a Computable General Equilibrium (CGE) model calibrated to the 2019 Input-Output data for Northern Ireland. Given the absence of a defined path for energy efficiency programs, we model various options, informed by stakeholder input and public information.

The three scenarios described below demonstrate different potential paths to residential energy efficiency improvements. They consider the implication of different funding mechanisms through which efficiency enhancing investment can be undertaken.

1. Insulation Retrofit Scheme: Based on information provided by industry stakeholders we model the impact of a Northern Ireland insulation retrofitting programme focused on the 'fabric first' approach. Within this scenario we model the economy-wide impact of investment in energy efficiency funded with a combination of public and private funding. We also evaluate the economy-wide impacts, considering household energy bill savings and their redistribution across other industries linked to household spending.
2. Extended Energy Efficiency Programme: Based on data from the Energy Saving Trust and Northern Ireland housing stock, we estimate the cost of upgrades to housing required for meeting net zero standards. For this extended energy efficiency scheme, information is provided on costs of loft insulation, double-glazing and wall insulation. This scenario involves similar upgrades to Scenario One but uses different data sources for cost and timing estimates.
3. Heat Pump Adoption for Household Decarbonisation: In addition to energy efficiency programmes, heat pumps are seen as a core part of the decarbonisation of household heating in Northern Ireland. We simulate three heat pump pathways to account for uncertainty around the feasibility of the installation – the first is based on the UK's sixth Carbon Budget, and the remaining two on UK household decarbonisation strategies. Within each pathway, an optimistic and pessimistic scenario with regards to cost reduction is simulated.

A final combination scenario (4) is also developed which combines both the extended energy efficiency programme with heat pumps is developed. The scale of the environmental impacts is dependent on the programme, with Table 1 outlining the key results for different simulations, which are detailed in Section 3.

Table 1. Summary results for all scenarios and simulations (between 2023-2050) [1]

	GVA (£m)	Employment (person years)	Emissions (MtCO2e)
Scenario 1: Insulation retrofit scheme			
Gross impact of demand shock only (1a)	730	3,940	-8.80
Gross impact with reduction in government spending(1b)	420	30	-8.80
Gross impacts with household spending (1c)	1,330	7,470	-8.80
Combination (1d)	1,020	3,560	-8.70
Scenario 2: Extended energy efficiency programme			
Gross impact of demand shock only (2a)	1,650	11,890	-8.40
Gross impacts with household spending (2b)	1,560	11,320	-8.40
Scenario 3: Heat pump programme			
6th Carbon Budget optimistic	1,500	11,420	-17.20
6th Carbon Budget pessimistic	2,100	15,850	-17.00
UK proportion optimistic	660	5,290	-7.50
UK proportion pessimistic	990	7,300	-7.50
UK proportion Net Zero optimistic	1,400	11,370	-15.90
UK proportion Net Zero pessimistic	1,810	14,410	-15.70
Scenario 4: Combined retrofit and heat pump programme			
6th Carbon Budget optimistic	2,600	17,820	-25.6
6th Carbon Budget pessimistic	3,190	22,180	-25.4
UK proportion optimistic	1,770	11,760	-15.9
UK proportion pessimistic	2,040	13,750	-15.9
UK proportion Net Zero optimistic	2,500	17,810	-24.3
UK proportion Net Zero pessimistic	2,910	20,800	-24.3

Source: Author's calculation

1 All prices in 2024 prices with GVA rounded to nearest £10, employment 10 person-years and Emissions 0.10MtCO2e.

1. Introduction

The Climate Change Act (Northern Ireland) 2022 (Northern Ireland Assembly, 2022) sets a target for Northern Ireland of net zero emissions by 2050, along with interim targets including an at least 48% reduction in net emissions by 2030.

The Act places requirements on Northern Ireland departments to develop and publish sectoral plans setting out how specific sectors will contribute to meeting the 2030, 2040 and 2050 emissions reduction targets. The Act requires DAERA to produce 5-year climate action plans (CAP) to set out the policies and proposals that Northern Ireland departments will implement to meet the corresponding 5-year carbon budget. Both the Sectoral Plans and policies and proposals within the CAP must support and have regard to a Just Transition through actions focussed on developing the green economy and tackling inequality. These principles were also central within the 2021 Energy Strategy for Northern Ireland: The Path to Net Zero (DfE, 2021). The Energy Strategy presented five key principles supporting the energy vision for Northern Ireland:

1. Placing you at the heart of our energy future.
2. Grow the green economy.
3. Do more with less.
4. Replace fossil fuels with renewable energy.
5. Create a flexible, resilient and integrated energy system.

This report aims to provide evidence on point 3: "Do more with less". This principle outlines the need to improve energy efficiency and proposes an investment strategy based on "energy efficiency first", meaning that support should first be aimed at reducing energy consumption by improving the building fabric of Northern Ireland. The ambition is that this will lead to less energy being used overall through a more efficient use of energy. This will help to target fuel poverty by driving down the cost of using energy, ensuring that consumers will benefit both from warmer homes and improved energy affordability.

One of the key strategic objectives of "Do more with less" is the target to deliver energy savings of 25% from buildings and industry by 2030 compared with 2021. In 2021 (the latest year where data is available), 22.5 million tonnes of carbon dioxide equivalent (MtCO2e) were emitted in Northern Ireland (DAERA, 2023). The Residential sector accounted for roughly 12% of these total emissions, with the majority of this produced by household heating (NAEI, 2023). By encouraging widespread energy efficiency measures for households that will reduce the amount of energy used by consumers, carbon emissions from this sector can be reduced. This will not only benefit consumers but also contribute towards the headline emissions targets set out in the Climate Change Act (Northern Ireland) 2022.

To deliver the 25% reduction in energy from buildings and industry by 2030 targeted in the NI Energy Strategy 2021, a policy framework was proposed to both introduce minimum standards for the energy efficiency of buildings, and to substantially increase funding and support for retrofitting buildings. One current funding programme is the Affordable Warmth Scheme, which aims to help low-income households with energy related matters and to target fuel poverty and energy efficiency (DfC, 2023a). Under the Scheme, private households are eligible to claim grant funding of up to £7,500 for energy efficiency upgrades to their home (NIHE, 2024a).

This grant can be used for:

- Insulation, ventilation, and draught-proofing
    - o Cavity wall and roof/loft insulation only
- Heating
    - o Replace boilers under certain circumstances
    - o Upgrade solid fuel, LPG or storage heater to gas or oil central heating
- Replace single glazed windows
- Solid Wall insulation
    - o Up to £10,000 may be granted for insulating houses of solid wall construction, but only if other measures have been completed

The upgrades must be carried out in priority order starting from the lowest cost improvements of insulation and draught-proofing before higher cost upgrades will be funded. An additional mechanism for household energy efficiency improvements was the now closed Boiler Replacement Scheme, which offered grants up to £1,000 for privately owned households to replace boilers over 15 years old (DfC, 2023b). The Northern Ireland Sustainable Energy Programme (NISEP) also offers funding for energy efficiency schemes, covering upgrades such as draught-proofing, LED light bulbs, or natural gas heating systems for low-income households with no central heating (Energy Saving Trust, 2024a). Administered by the Energy Saving Trust, the NISEP fund is gathered from all Northern Ireland electricity customers through a public service obligation, with £8 million available for households. Most of this funding is reserved for low-income households, where they can receive full funding to undertake upgrades. However, grants towards the cost of certain measures are also available for households which do not qualify for the priority funding.

Typically, the main espoused benefits of energy efficiency measures lie in reducing the amount of energy used, and the resulting reduction in greenhouse gas (GHG) emissions when fossil fuels are part of the energy production mix. However, there is a supporting body of literature and studies that also consider the other potential benefits of energy efficiency improvements (e.g. Ryan and Campbell, 2012 and Figus et al., 2017). Firstly, there are the economic benefits at a household level that can be achieved through reduction in the cost of using energy in terms of additional disposable income. This in turn may reduce fuel poverty and improve comfort in general. Secondly, the income freed up from energy consumption may be spent on other goods and services which can lead to an additional increase in economic activity.

It should be noted that improved energy efficiency may lead to rebound effects (Figus et al., 2017). This is a situation where actual energy savings from improved energy efficiency are smaller than expected energy savings due to consumers' response to reduced energy cost. The literature suggests that the rebound may only partly erode energy savings associated with energy efficiency improvements. In some cases it may be due to comfort taking for households that were not previously heating their homes at an appropriate level. However, it should be noted that this is not explicitly included in our scenarios due to lack of data on the change in energy use for comfort in these households.

In this report we investigate the economy-wide impacts of undertaking measures to improve energy efficiency in Northern Ireland. The remainder of the report is presented as follows: in Section 2 we present the modelling framework used to estimate the economic impacts, along with a description of the emissions data used to calculate potential savings. Section 3 details the different scenarios which were modelled and the data supporting them, while Section 4 presents the key results. Section 5 concludes the report.

2. Modelling Framework

We employ a multi-sectoral computable general equilibrium (CGE) model of the Northern Ireland economy. The model captures the key interlinkages between industries in the private sector, households, government, international trade, and the labour market. These models allow for extensive simulations of scenarios on the impact of a wide range of policy interventions. They are frequently used by governments to forecast or predict the merits of alternative policy choices[2].

The model used for this work is calibrated on a 30-sector Social Accounting Matrix for Northern Ireland for 2019 – the most recent calendar year of the published Northern Ireland Input-Output Table (IOT) (NISRA, 2023a). In addition to the 30 sectors within the model there are three internal institutions – households, firms and governments – and two external, the rest of the UK (RUK) and the rest of the world (ROW). Northern Ireland is a small, open, regional economy in that price changes in Northern Ireland do not impact upon the rest of the UK or global markets. Markets for goods and services within the model are assumed to be competitive with the rest of the UK and the rest of the world.

This framework has been used extensively in a wide range of applications and this specific version was built for the Department for the Economy for policy analysis (see Duparc-Portier and Figus, 2021, and Comerford et al., 2023). The model allows for a degree of flexibility in the choice of assumptions on how the economy is set up and reacts to changes. The version used in this modelling assumes that industries and households within the model have no future expectations of prices and are only reactive to changes in demand/supply or prices.

The model assumes that producers minimise cost of production output by using capital labour and intermediate inputs (including energy). Domestically produced intermediate inputs are combined with inputs imported from the RUK and ROW and are imperfect substitute. Output produced by firms is sold to household, investment, government, and exported.

The supply side of the economy determines the use of capital and labour in the model. Capital, in the first period, is fixed but in subsequent periods the capital stock of each sector is updated through investment, which responds partially to the gap between the desired and actual (adjusted for depreciation) levels of capital stock – in line with the neoclassical investment formulation (Jorgenson, 1963). Capital is immobile between sectors.

A core advantage of CGE modelling over other appraisal methods such as Input-Output (IO) is that both the demand and supply-side of the economy are explicitly modelled through the introduction of supply constraints and price sensitivity behaviour. Thus, there are potential 'crowding-out' effects whereby some industries actually lose out due to the increases in prices.

All scenarios are run in a multi-year setting. Overall, the scenarios run until 2050 with year one being 2023. The model is initially assumed to be in steady-state equilibrium, implying that, with no exogenous disturbance, the model simply replicates initial values over all subsequent time periods.

2 See FAI (2022) for a review of the AMOS framework of energy and environmental applications.

2.1 Greenhouse Gas Emissions

As the purpose of this modelling is to measure the impact of energy efficiency improvements, the model described above was environmentally extended to include the assessment of Greenhouse Gas (GHG) emissions[3]. The GHG emissions due to fuel use of Northern Ireland for the year 2019 were calculated from the usage of fossil fuels by industry and consumers. The usage of different types of fuels[4] across all sectors of the economy and households in the UK are published by the Office for National Statistics (ONS, 2022). For each of these fuel types in 2019, the corresponding CO2 equivalent emissions per sector were calculated using standard, fuel-specific conversion factors (DESNZ & BEIS, 2022). The emissions, in MtCO2e, for each fuel were summated to calculate the total GHG emissions per sector. As this fuel use data was produced only for UK level, with no information on the shares per devolved nation, the Northern Ireland emissions were estimated as a proportion of the UK total. We compared the output (the sum of all goods and services produced that year) for each industrial sector in the UK IOT and the Northern Ireland IOT for 2019, and used the ratio of these sectoral outputs to scale the total fuel use GHG emissions for each sector at the UK level to provide the Northern Ireland levels.

While this methodology has been successfully applied to other regions of the UK, there are potential limitations due to the unique fuel usage patterns in Northern Ireland compared to the rest of the UK. To address this, our method is enhanced by comparing our results with the Northern Ireland Greenhouse Gas Inventory (DAERA, 2023). While the greenhouse gas inventory lacks detailed industrial data for direct use in the CGE model, we utilise consumption by source totals as controls. These totals allow us to scale our fuel usage figures, ensuring sectoral emissions align with the published greenhouse gas inventory.

Within our model, emissions changes stem from two sources. Firstly, there is a reduction in emissions associated with household greening, whether through energy efficiency programs or heat pump installations. Secondly, emissions result from changes in household spending patterns due to savings in heating costs. As households become more energy efficient, they save on energy bills, which they can then spend on other goods and services in the economy, generating associated emissions. This dual consideration enables a comprehensive analysis of emissions dynamics within the model.

3 See Allan et al. (2018) for a discussion on incorporating emissions into CGE modelling.

4 Coal, natural gas, petrol, diesel, fuel oil, gas oil, aviation fuels and an aggregate ‘other fuels’ category.

3. Simulation Strategy

We carry out a range of scenarios to measure the economy-wide impacts of household decarbonisation improvements in Northern Ireland. Each of these scenarios are carried out individually to determine the impacts in isolation.

3.1 Scenario One – Economic Impact of Northern Ireland-wide Insulation Retrofit Scheme

The first scenario considers the potential economic impact of the roll-out of a Northern Ireland-wide scheme to retrofit household insulation. Enhancing the provision of insulation in homes is a well-recognised method of improving energy efficiency and thermal comfort (Energy Saving Trust, 2024b). Much heat is lost in households through uninsulated walls or roofs, but cavity wall, solid wall, and loft insulation can greatly reduce the amount which escapes. By reducing heat loss, savings can be delivered on energy bills by not wasting energy to heat rooms which will not remain warm. These impacts support the dual aims of the 2021 NI Energy Strategy and the Climate Change Act (Northern Ireland) 2022 to not only reduce Northern Ireland emissions, but to also alleviate social issues, such as fuel poverty.

While schemes to date (e.g. Affordable Warmth Scheme and NISEP) have targeted multiple types of efficiency improvements, growing evidence advises a 'fabric first' approach (Mac Uidhir et al., 2020). By focusing initial energy efficiency measures on retrofit installations, such as cavity wall insulation (CWI) and loft insulation, which are relatively simple to undertake, buildings can be improved in a short timeframe to minimise their heat loss. This means that if and when other measures, such as heat pumps are installed in the future, less electricity is required to run them as the leakage of heat from the building has been reduced with the insulation. The 'fabric first' methodology has previously been highlighted as a key principle of decarbonising the built environment in the Republic of Ireland National Mitigation Plan (DECC, 2017).

As such, the first simulation in our modelling assesses the potential impacts of employing this 'fabric first' approach – with retrofitting measures for CWI and loft insulation considered in isolation from other types of energy efficiency interventions.

The Northern Ireland housing stock is approximately 800,000 households, with over 70% of these either owned outright or with a mortgage (NISRA, 2023b). Following consultation with industry stakeholders to inform scenario planning, certain housing types were excluded from the initial proposal:

- Housing association properties (NIHE and others)[5]
- Flats/apartments – majority excluded as cost is high versus potential benefits
- New properties (since 2000) – in compliance with Building Regulations on energy efficiency
- Solid wall type properties

Solid wall insulation is a larger undertaking than insulating a property with cavity walls. Unlike cavity walls there is no space to inject insulation, instead a more complex procedure of installing insulation boards on internal walls or layering insulation and cladding on external walls is required (Energy

5 From stakeholder suggestion - social housing providers are obligated to provide adequate levels of insulation under Decent Homes Standard. As such, they are outwith the scope of this proposal.

Saving Trust, 2024b). This rise in complexity means there is a corresponding increase in cost. As such, through discussion with industry stakeholders, houses of solid wall construction are excluded in this scenario.

After excluding the above properties, we propose a scenario where 450,000 homes in Northern Ireland are eligible for cavity wall insulation upgrades. Within this, a subset of 300,000 households will also be upgraded to improved levels of loft insulation.

With regards to the costs involved in these insulation upgrades, values were informed through discussion with industry stakeholders in Northern Ireland. Considering first CWI, a combination of measures is likely to be required. Some homes are expected to currently have empty cavities or cavities which will only need a top up of insulation, through discussion it was estimated that the number of houses with empty cavities to be 50k and further 100k only needing a top up. These measures are the simplest and in turn the cheapest interventions, with costs[6] estimated by Northern Ireland industry stakeholders at £805 to fill an empty cavity and £730 for a partial fill. However, based on industry information, the majority of the households are predicted to need an extraction of current, not fit-for-purpose insulation before a complete re-fill of upgraded CWI. The increased work required for this measure is reflected in the cost, estimated at £2,195 per household. Combined, the total predicted cost for CWI intervention across the 450,000 homes included in the scenario is £772million.

Loft insulation is priced separately, with costs detailed for two distinct measures. An estimated 200k homes will require top-ups of existing insulation from 100mm to the recommended 300mm thickness. The associated cost with this level of installation is £975 per household. The remaining 100k homes are predicted to require a top-up from 200mm to 300mm. The cost for this is outlined as £730 per household. Combined, loft insulation for the identified 300,000 homes is estimated, based on figures provided by industry stakeholders, to cost £268million.

Overall, the costs of this Northern Ireland-wide insulation retrofitting scheme (henceforth 'scheme') total £1.04billion to upgrade CWI in 450,000 homes and loft insulation in 300,000 homes. Additionally, an administration fee is budgeted for in the scenario to account for the costs of delivering the upgrades to households. This was set on industry best-practice at 7% of the total predicted spend of the scheme, totalling £73million. In total, the cost associated with the scenario is expected to be £1.11billion.

Following industry expert advice, the programme of installing all of the measures outlined above is expected to take 15 years. As such, the cost of the scheme is, on average, £74million per year when combining all insulation measures and the administration fee.

3.1.1 Scenario One (a) – Gross Impact of demand shock only

In this first scenario, the potential economic impact of the £1.11billion investment is considered in isolation, solely as investment in the economy independent of the source of funding. We assume there is equal investment in each year of the scheme, with an average annual cost for the insulation measures at £69million and £5million for the administration fee. The spend on installing the insulation measures is assumed to all be in the construction sector (S14[7]), while the administration fee is spent under 'Activities of head offices and management consultancy' (S25).

In reality, there are compounding factors to consider – such as the inclusion of potential savings on household energy bills and accounting for the impact on spending from Government and Households

6 All costs are given in 2024 prices.
7 See Table A.1 in Appendix for the list of sectors used in the model.

on the measures outlined in the scheme. However, this first scenario is intended as a benchmark, solely to assess the potential impact of the level of investment identified for the scheme. Extensions to this 'base case' are discussed in following scenarios.

3.1.2 Scenario One (b) – Gross impact with reduction in government spending

The funding of the insulation scheme may be a combination of Government grants and contributions from the household 'able-to-pay' (ATP) market. Given this, the total £1.11billion investment predicted will be sourced from both household budgets and the Government budget. Fuel-poor households may receive full Government funding to carry out energy efficiency upgrades of CWI and loft insulation. In order to stimulate a high enough uptake of insulation upgrades in the remaining ATP households, Government financing may be required to subsidise the costs in the form of grants. Through engagement with industry stakeholders, 20% of the £1.04billion insulation budget is determined to be required for fully funding upgrades to fuel-poor households, a total of £208million. The remaining funding will be evenly split between Government grants and contributions from ATP households, each contributing £416million investment. Total Government spend over the lifetime of the scheme is thus predicted to be £698million, averaging £47million per annum, when the administration fee is included. Household spend is predicted at £416million, or a contribution of £28million annually.

The Government contribution of £698million over 15 years is a significant amount, and £47million per annum is a non-trivial investment. For this scenario, we assume that this investment will mean Government funds have to be reallocated based on current government spending. Table 2 outlines the reduction in government spend across industries which we use in our modelling.

Table 2. Government expenditure in Northern Ireland and reduction related to the investment in insulation scheme[8].

	Percentage of Government Expenditure [%]	Reduction in expenditure [£m p.a.]
Agriculture	0.04	0.020
Electricity transmission and distribution, gas distribution, steam and air conditioning distribution and supply	<0.01	0.001
Water supply; sewerage and waste management	3.89	1.808
Construction	1.38	0.641
Wholesale and retail	0.18	0.086
Communication	0.28	0.132
Activities of head offices and management consultancy	0.02	0.009
Other professional services	0.02	0.009
Rental and travel agents	<0.01	0.001
Administration and building services	<0.01	0.001
Public services	91.45	42.526
Other services	2.72	1.267
Total	***99.99***	***46.501***

Source: Government expenditure percentages from NISRA (2023a)

8 Sectors with less than 0.01% government expenditure or £0.001million absolute reduction are not shown. The remaining sectors in Table 1 account for 99.999% of expenditure.

3.1.3 Scenario One (c) – Gross impact with Household spending

As discussed in Section 3.1.2, our scenario for a Northern Ireland-wide insulation retrofitting scheme is partially funded by Government and partially by households who are able to contribute to their upgrades. The required household spend from able to pay is estimated at £416million over the 15-year period of the scheme, with an average investment of £28million per year.

This scenario, 1(c), considers the overall economic impact when household spending is taken into account. Firstly, there is the absolute change in household expenditure due to payments to the construction sector to carry out the insulation upgrade. As with the government spend in Section 3.1.2, this investment is treated as a reallocation based on current spend. Secondly, the energy efficiency improvements will reduce the amount of energy required to heat homes – thus reducing expenditure on energy bills. It is estimated that the combined CWI and loft insulation scheme reaching 450,000 households will result in estimate from industry total fuel bill savings of £90million per annum once the rollout is complete.

3.1.4 Scenario One (d) – Combination (gross impacts with changes in government and household spending)

In the previous simulations the focus has been on isolating impacts. In this final simulation for Scenario One we combine the impacts of investment with government and household spending changes. For households, both the spend on the insulation measures and the subsequent savings on energy bills being re-spent into the economy are modelled.

We additionally consider a sensitivity analysis on the share of government versus household spend on the £832million investment. The relative shares are varied from 0 – 100% to demonstrate the impact of varying levels of government investment.

One of the primary objectives of carrying out energy efficiency improvements, such as household insulation, is to reduce the greenhouse gas emissions associated with energy use. As such, the emissions impact of the proposed insulation scheme is also modelled. Through consultation with industry stakeholders in Northern Ireland, we consider that CWI and loft insulation upgrades will on average save each household 818kgCO2e and 270kgCO2e per year respectively. These installations combine to provide total emissions savings of 0.45MtCO2e per year after completion of the rollout. This represents a significant saving (17%) on the estimated 2.7MtCO2e of emissions from the Residential sector in 2019 (NAEI, 2023).

3.2 Scenario Two – Economic Impact of Extended Energy Efficiency Programme

In Scenario One, cost estimates were produced using information provided to the research team from industry stakeholders. In addition to Scenario One, we simulate another insulation upgrade pathway using publicly available information on upgrade costs and the housing stock. Combining information on the housing stock in Northern Ireland with costings from the Energy Saving Trust, we can simulate another insulation pathway. The Energy Saving Trust outline three key areas of housing upgrades which improve the standard of heat reduction in households: loft insulation, double-glazing and wall insulation (Energy Saving Trust, 2024b).

The most recent Household Condition Survey in Northern Ireland details the level of loft insulation by household type and tenure (NIHE, 2024b). Loft insulation is classified by thickness with six levels identified: no insulation, less than 100mm, 100 to 150 mm, 150 to 250mm, 250 to 300 mm, and above 300mm[9]. Through discussions with experts, it was noted that for Northern Ireland to reach its energy reduction goals then households should have loft insulation of at least 250mm. From the housing dataset, 432,000 homes in Northern Ireland do not have sufficient levels of loft insulation. From the Energy Saving Trust website the average cost of upgrade for loft insulation in households in Northern Ireland which currently have less than 150mm is £960, and £887 for homes with insulation between 150 -250mm[10]. Overall the cost of upgrading loft insulation in Northern Ireland for this scenario is in the region of £390million, which we assume takes place over a 15-year period, similar to Scenario One.

Double-glazing is another key upgrade in household energy efficiency programmes. Currently the vast majority (86%) of households in Northern Ireland have full double-glazing – with only 91,300 needing an upgrade (NIHE, 2024b). However, double-glazing is much more expensive than other types of household energy efficiency upgrades with the cost of installing a set of double-glazing windows in an average household in Northern Ireland estimated to be £15,000 (Energy Saving Trust, 2024b). This means to bring the housing stock glazing up to standard will cost a total of £1.3billion.

The final type of upgrade outlined by the Energy Saving Trust is wall insulation upgrades, similar to that outlined in the previous Scenario. From the housing database it is estimated that around 245,000 homes in Northern Ireland will need some type of wall upgrade if energy reduction targets towards net zero are to be realised. Combining the Housing Condition Survey data with cost estimates from the Energy Saving Trust: 79% of the 245,000 households need cavity upgrades at an average cost of £833; 9,820 (4%) of the homes need timber frame upgrades costing £19,500; and 36,800 homes need solid wall upgrades again at a cost of £19,500. Overall we find the total of wall insulation upgrades to be £1.08 billion.

In Summary, the total insulation upgrades (loft, glazing and walls) using the Energy Saving Trust costings and the Housing Condition Survey is estimated to be £2.83 billion (more than double that of Scenario one).

3.3 Scenario Three – Economic Impact of Heat Pump Programme

In addition to the 'fabric first' energy efficiency intervention of retrofitting insulation to households, further measures are likely to also be required to meet the targeted 25% energy savings from buildings that the 2021 Energy Strategy for Northern Ireland proposes. The fourth principle in the Energy Strategy, "Replace fossil fuels with renewable energy", additionally outlines the need to decarbonise heating in Northern Ireland. Approximately two thirds of homes in Northern Ireland still use oil for their central heating, with most of the remainder utilising natural gas from the gas grid (NISRA, 2023b). Heating oil is more polluting as a fuel source than natural gas, but many rural properties in Northern Ireland do not currently have the option to join the gas grid as it does not extend to all areas (Energy Saving Trust, 2020).

In order to transition away from the reliance on fossil fuels for home heating and meet the goals of the Energy Strategy and Climate Change Act (Northern Ireland) 2022, a number of options are likely to be required. These have been postulated as extending the gas network to target those homes using oil; decarbonising the gas used on the grid; transitioning to lower carbon fuels; and electrifying heat through the use of heat pumps (DfE, 2021). We consider the latter suggestion of heat pumps in our scenario[11].

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9 These classifications are from the Energy Saving Trust costings but are not available in as much detail in the Housing Condition Survey. Assumptions around of the number of households of each thickness within the Housings Condition Survey are made.

10 The cost for insulating detached bungalows is excluded from this calculation, as loft insulation for this housing type was not counted in the Housing Condition Survey 2016 (NIHE, 2024b).

11 Hybrid heat pumps are not assessed.

3.3.1. Scenario Three (a) – Demand impact of heat pumps

Following the same stages indicated in Section 3.1, we model the impact first considering only the demand shock of the overall investment in heat pumps; before considering the impact due to a reduction in Government spending due to any grants or loans to household, and the impact on household expenditure. The potential emissions savings when moving from fossil fuel heating to heat pumps are also assessed.

While there is an expected increase in the installation and use of heat pumps in Northern Ireland, the pathway of development is less certain. To account for this uncertainty we model three separate pathways for heat pump installation in Northern Ireland – the first is based on the UK's sixth Carbon Budget, and the remaining two on UK household decarbonisation strategies.

The 6th Carbon Budget, published in 2020, outlines the actions required for the UK to reduce emissions to 22% of 1990 levels by 2035 on the way to becoming net zero in 2050 (CCC, 2021). Within the report are a series of scenarios on how the UK can reach these targets, with many different technologies included in the pathways. For this report the focus is on the proposed installation of heat pumps which is separated into existing and new households by year (up to 2050) for each of the four UK nations. As the main focus of the Carbon Budget is on reaching net zero these are rather optimistic numbers with an estimate of 739,830 heat pumps installed in Northern Ireland by 2050.

Through discussion with stakeholders there is serious doubt on whether the 6th Carbon Budget heat pump numbers are realistic for Northern Ireland, thus in this report two other heat pump pathways are developed. Both of these are based on the UK Heat Pump Investment Roadmap (DESNZ & DBT, 2023). Published in 2023, the Roadmap outlines key policies the UK government plans to introduce to drive investment and installation of heat pumps in the next decade. These include the development of a supportive policy and regulatory environment coupled with incentives to drive innovation and investment in a local supply chain. Key for this report is the goal of installing 600,000 heat pumps per year in the UK by 2028, half (300,000) of which are produced locally.

Thus for the second development pathway for heat pumps in Northern Ireland we proportion this 600,000 UK target based on number of households. The number of households in Northern is 3% that of the UK total, so scaling the UK heat pump targets we estimate that the yearly number of heat pump installations in Northern Ireland will be 18,000. Northern Ireland, due to a number of reasons outside the scope of this report, is significantly behind the current overall UK heat-pump position with only 892 heat pumps being recorded in the 2021 NI Census. Taking account of this we push back the target year to 2031 instead of 2028 for the UK and assume a linear growth in installation from 2023 to 2031.

Recently there has been debate on whether the UK target of 600,000 yearly installs is enough if the UK is to reach its net zero commitments by 2050. A recent study notes that if net zero is to be reached in the desired timeframe, then a further 1.1 million (1.7 million in total) heat pumps need to be installed in the UK yearly (WBS, 2023). This is the basis of the third scenario where we again proportion this number for Northern Ireland, so that a total of 51,000 heat pumps are being installed annually. Again, similar to the first scenario (from the 6th Carbon Budget), while this is the number needed to reach environmental goals it may not be the most realistic in terms of the economic and supply chain capacity.

With the pathways outlined we now estimate total costs of each, which requires estimation of cost of heat pump systems. Currently heat pump systems are much more expensive than traditional gas heating system, through discussion with industry, a unit in 2024 is in the region of £8,500 with a further £5,500 in installation costs. This gives a total of £14,000 for a household to install a heat pump system, compared to a cost of up to £5,550 for traditional boilers. For heat pumps to become commercially viable there needs to be a significant cost reduction to make them comparable with current systems, and indeed the UK government has set cost reduction targets. The Heat and Buildings Strategy set an ambition for heat pump costs to reduce at least 25% by 2025, and for them to be cost competitive with traditional boiler systems by 2030 (UKERC, 2023). However, to date there has been little progress on the cost reduction front with recent estimates that heat pumps will only reduce costs by 30% by 2030 and will not reach cost parity with traditional systems by 2035 at the earliest.

Given the uncertainty in the cost reduction of heat pumps, two cost estimates are made for each scenario – one optimistic and one pessimistic. For the optimistic scenario, the assumption is made that 25% of the cost reduction is met by 2025 and costs for heat pumps are £2,000 (the cost of current expensive boilers) by 2030 with cost reduction following a linear projection. The pessimistic scenario follows a similar linear decrease but cost of heat pumps only reduce by 30% by 2030 and don't reach £2,000 until 2035. As more installers are certified and systems are streamlined it would be expected that installation costs also decrease, for this we have assumed that these decrease in line with cost reduction percentages of the units.

3.3.2. Scenario Three (b) – Impact of heat pumps with Government Spend

As there is no current Northern Ireland programme which specifically targets the funding of wide scale heat pump installation, we assume a possible pathway based on the Boiler Upgrade Scheme (BUS) in England and Wales (OFGEM, 2024). Under this scheme, up to £7,500 can be claimed towards the cost and installation of a heat pump in homes and non-domestic buildings. The total funding amount available is £450million, covering a 3-year investment period from 2022 to 2025. To create an equivalent Northern Ireland scenario, we scale the funding available by the Northern Ireland population as a proportion of the England and Wales population, for a per capita comparison. This results in £14.1million of funding to be spent over a 3-year period, which we assume as 2026 to 2028, with £4.7million available each year.

This £4.7million represents only a small fraction of the cost of installing heat pumps in these years that is calculated for the pathways outlined in Section 3.3.1, with these calculations shown in Table 3. In the absence of any other potential funding source, only the impact with this reduction in government spend is modelled.

Table 3. Cost of heat pump installation in years 2026 – 2028 for each pathway

	Total Cost of Heat Pumps and Installation (£m)		
	2026	**2027**	**2028**
6th Carbon Budget optimistic	288.6	287.0	254.7
6th Carbon Budget pessimistic	388.7	437.0	453.6
UK proportion optimistic	74.5	81.3	81.0
UK proportion pessimistic	100.3	123.7	144.2
UK proportion Net Zero optimistic	74.5	81.3	81.0
UK proportion Net Zero pessimistic	100.3	123.7	144.2

Source: Author's calculation

3.4 Scenario Four – Economic Impact of Combined Retrofit and Heat Pump Programme

It is likely that to meet the goals of the Energy Strategy for Northern Ireland and the Climate Change Act (Northern Ireland) 2022, more than one energy efficiency measure will have to be implemented. To that end, in addition to the standalone household retrofit and heat pump programmes outlined in Sections 3.2 and 3.3, we also propose a scenario where a combined scheme targets both retrofitting homes with improved insulation and helps them to transition away from fossil fuel heating sources.

The amount of energy required to heat a home using a newly installed heat pump is minimised with the addition of insulation measures, as the heat leakage from walls and roofs will have been reduced. This is the supporting idea behind 'fabric first' interventions, and ensures that the coefficient of performance of heat pump are maximised.

We here utilise the publicly available data on housing stock from the Northern Ireland housing survey and costs from the Energy Saving Trust in the extended energy efficiency scenario, and consider this in conjunction with each of the heat pump pathways outlined in Section 3.3. For funding, we assume that government will fund 20% of the insulation measures (targeting fuel poor households only), and will provide a £14.1million fund over 2026 – 2028 for heat pump installations as per Scenario 3(b). This is intended as just one possibility for a combined programme, and to give an indication of the potential impact when a more widescale investment is delivered.

4. Results

4.1 Scenario One – Economic Impact of Northern Ireland-wide Insulation Retrofit

For each scenario, the economic impacts are compared with that of counterfactual known as the business-as-usual case (BAU), i.e. no investment in the energy efficiency upgrades. This counterfactual is the 2019 Northern Ireland economy which grows at a stable rate (based on previous growth) each year and the results are interpreted as an increase/decrease in economic indicator compared to the BAU case, for example a 1% increase is 1% increase in GVA compared to the BAU case at a particular period in time. Additionally, some results throughout the report are also compared with other scenarios, this comparative analysis is common practice in economic appraisals allowing for the examination of different simulations/scenarios and their impacts relative to each other.

4.1.1. Scenario One (a) – Impact of demand shock only

Over the period of 2023-2050 with the proposed Northern Ireland-wide insulation scheme, we estimate that Gross Value Added (GVA) will increase by £730 million and that the scheme would support an extra 3,940 person years[12] of employment. Table 4 highlights the estimated impact on some key metrics in different years – the first year of investment (2023), part-way through the scheme (2027), the end of the scheme (2037), and after the investment through the scheme has ended (2038).

Table 4. Key results throughout period of investment, % change from BAU[13]

	2023	2027	2037	2038
Gross Value Added	0.01%	0.06%	0.09%	0.08%
Employment	0.02%	0.03%	0.04%	0.02%
Real wage	0.05%	0.09%	0.11%	0.06%
Household consumption	0.10%	0.12%	0.13%	0.03%
Investment (£m)	0.30%	0.20%	0.16%	-0.15%
Consumer price index (CPI)	0.06%	0.06%	0.05%	-0.01%

Source: Author's calculation

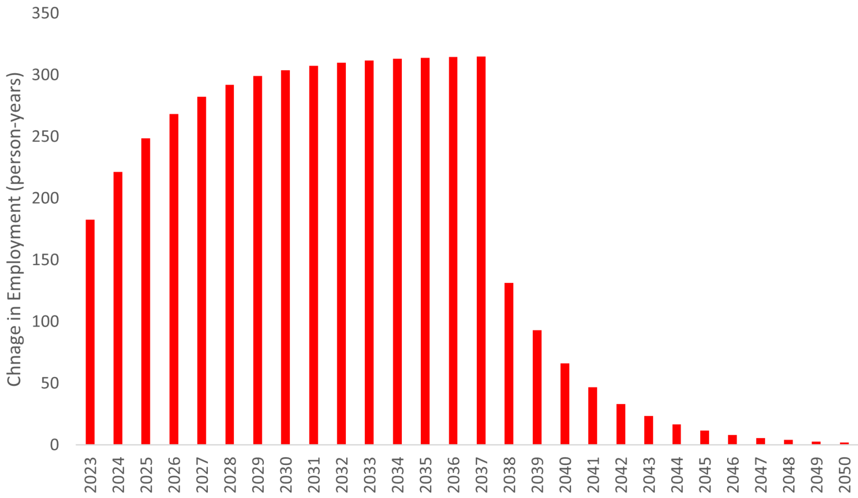
The results in Table 4 show that even after the demand shock through the investment in the scheme, there are legacy effects (i.e. economic impacts after period of investment ends) and some impacts persist. As one would expect, additional employment is stimulated through investment in the insulation scheme – primarily in the Construction sector where there was increased demand of £69million per annum. The impact on employment in the Construction sector from BAU due to the change in demand is highlighted in Figure 1. This increase in employment peaks in 2037 showing the point of maximum impact of the scheme, before dropping off sharply when the investment returns to base level. This drop off can also be seen in the results for 2039 in Table 4. In the last column of Table 4 both investment and CPI are negative, this notes that these are lower at this time-period than if the investment had not occurred. For investment this occurs as the build up of physical capital (such as

12 Person-years is the equivalent to the employment of 1 full time employee over the period of a year. This is a standard economic measurement used when dealing with impacts over time.

13 Table A2 gives definition of variables

machinery) in the previous years depreciates, and CPI is lowers as there is a significant drop off in demand in goods and services when investment in the scheme ends. Over the full simulation period however (2023-2050) there is an overall positive impact on investment and CPI.

Figure 1. Change in employment from BAU in Construction sector (S14) for Scenario One (a)

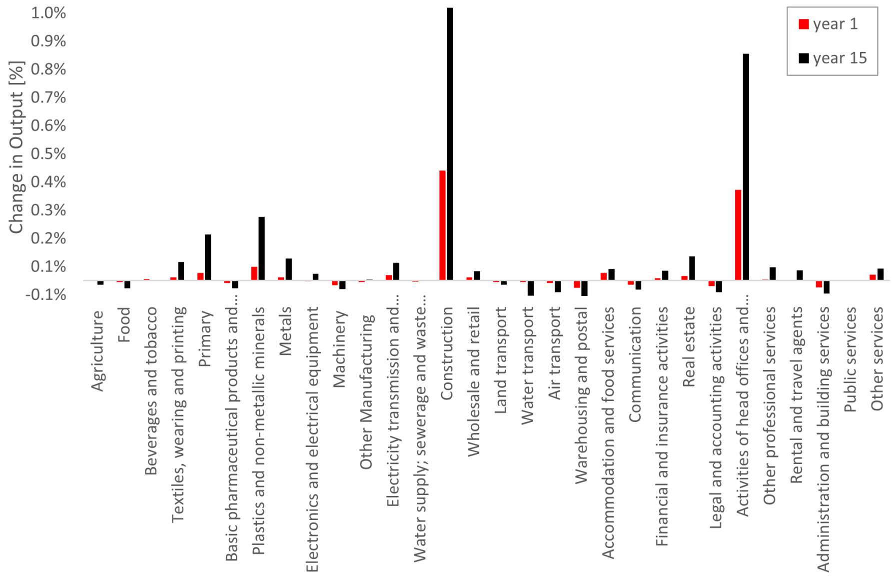


Source: Author's calculation

While the results in Table 4 indicate an overall increase in each metric in percentage terms throughout the lifetime of the scheme, in reality the 'crowding-out' effect that was discussed in Section 2 means that not all industries of the economy experience positive change. Figure 2 shows the sectoral change in output in the start and end years of the insulation scheme.

As would be expected, the Construction and Activities of Head Offices sectors see the largest change in output, as they received direct investment through the scheme each year of £69million and £5million respectively. Other sectors such as Primary, Plastics & Non-metallic Minerals, and Metals see a slight increase in their output as they are within the direct supply chain of the sectors receiving investment. The crowding-out effects see a reduction in output in other sectors such as Water and Air Transport, Warehousing and Postal, Legal and Accounting activities, and Administration and Building Services – which all experience a reduction in output of around 0.05%. This is primary driven by the increase in production costs, due to increased CPI throughout Northern Ireland, in these industries making them less competitive on the global market, which in turn reduces their exports.

Figure 2. Change in output for each sector, start and end year of Scenario One (a)



Source: Author's calculation

4.1.2 Scenario One (b) –Gross impact with reduction in government spending

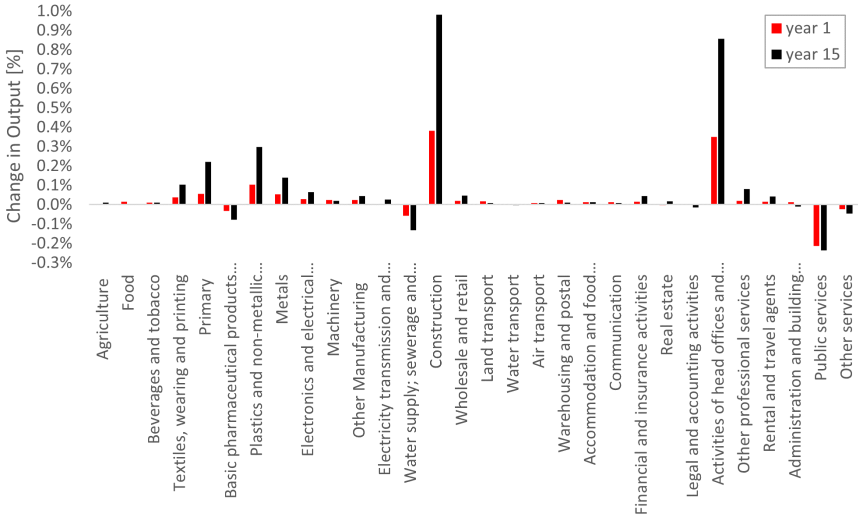
In this scenario, the £697million spend on the insulation scheme by Government is accounted for. We assume that the budget must remain balanced, so the investment in the scheme is funded through the reallocation of Government funds based on the spending pattern in 2019 (NISRA, 2023a).

We find that over the 15 years of the insulation scheme, an increase in GVA of £420m is supported when accounting for the reduction in Government spend on other aspects. At a sectoral level this is evidenced by an increase in jobs in areas such as Construction, but these are offset by a larger decrease in Public Services – assumed to be the sector which experiences the majority of the reduction in Government investment within this scenario.

Considering the output of each sector, the percentage changes in years 1 and 15 are shown in Figure 3. Comparing this with the case of the demand shock only in Figure 2 shows that the sectors which experience increases or decreases in output have changed. As is to be expected, the largest decrease in output is seen in Public Services, accounting for the reduction in Government spend. However, some sectors which showed a reduction in Scenario 1(a) (e.g. Water and Air Transport, Warehousing and Postal) now see a positive change in output. Others see an increase in year 1 but a decrease by year 15 (e.g. Legal and Accounting, Administration and Building Services).

Overall, despite the reduction in Government spending to account for funding the insulation proposal, there is still an increase in GVA. The reduction in total employment numbers is due to the relative labour intensity of different sectors, and the higher capital intensity of the Construction sector which receives the majority of the investment through the scheme.

Figure 3. Change in output for each sector, start and end year of Scenario One (b)



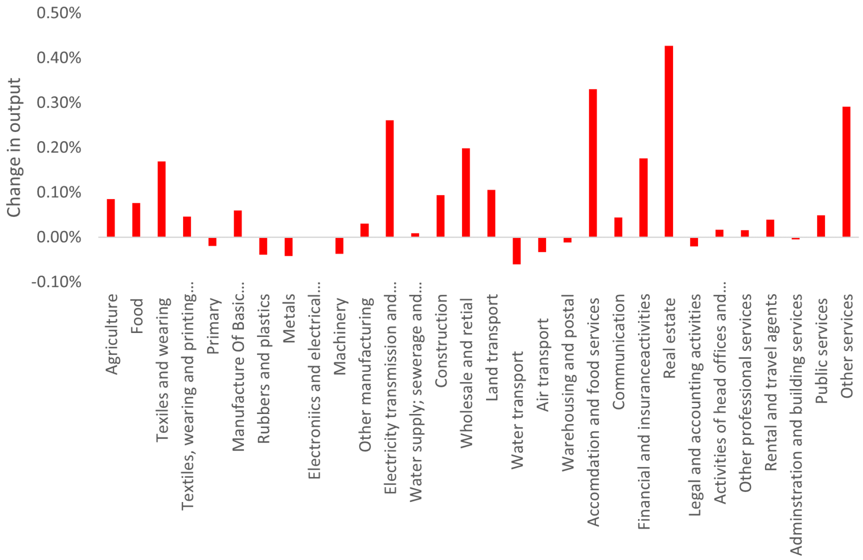
Source: Author's calculation

4.1.3 Scenario One (c) – Gross impact with Household spending

As detailed in Section 3.1.3 there are two competing effects for households related to energy efficiency improvements – the cost of upgrades and the savings from the reduction in the amount spend on heating the home. While the simulation runs until 2050, the upgrade programme itself only lasts for 15 years so there is a period of 12 years (2038 to 2050) where only the savings are modelled. Overall we estimate that, accounting for household spending upgrades and the associated energy savings, by 2050 there will be an increase in GVA of £1.33billion and employment of 7,470 person-years of employment. This represents a 82% and 89% increase for GVA and employment respectively compared with only the demand shock (Scenario 1(a)). The relatively larger increase in employment is attributed to the labour-intensive nature of the goods and services purchased by households with their energy savings. Sectoral impacts are outlined in Figure 4.

In Figure 2 it is shown that some industries in the Northern Ireland lose out due to the 'crowding-out' effect linked to the increase in production costs throughout the economy, decreasing international competitiveness. Comparing the results from Figure 2 with the above Figure 4, it is evident that the increase in household consumption negates some of this crowding-out effect as many industries that previously had a reduced output compared with the BAU case now have a positive impact. For example, Agriculture and Manufacturing of Food are now positive, and Accommodation and Food Services has a larger impact compared with Scenario 1(a). While prices are still high in Scenario 1(c), the increase in household consumption counteracts the loss of exports in many industries.

Figure 4. Percentage change in output from BAU across industries for Scenario 1(c)



Source: Author's calculations

4.1.4 Scenario One (d) – Combination

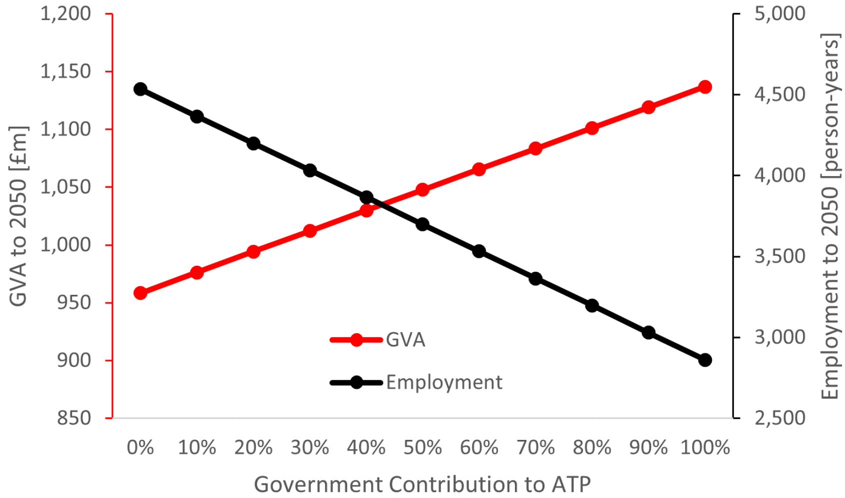
The final simulation for Scenario One combines aspects from Scenarios 1(b) and 1(c), incorporating both investment and changes in both government and household spending. As expected, when accounting for government-funded upgrades for households, the overall economic impact is slightly lower compared to Scenario 1(c). Nonetheless, there is still a significant increase in GVA by 2050, amounting to £1.02 billion, along with an increase in employment of 3,560 person-years.

We additionally carried out a sensitivity analysis on the scale of government funding, varying the share paid by government and ATP households. We assumed that government would continue to fund the 20% of the insulation total for fuel-poor households in all cases, for a total of £208million. The remaining £832million was split between government and households in 10% increments – starting from the case where households paid 100% of the remaining budget and government contributed 0%, to a case where household contribution was zero and government paid for 100% of the upgrades. The results of this analysis are summarised in Figure 5, and presented in more detail in Section A.3.1 of the appendix.

In addition to economic changes, we analyse the carbon reduction achieved through the insulation program. There are two competing forces at play: the reduction linked to decreased heating usage and the increase resulting from households consuming other goods and services. Based on stakeholder input, the full energy efficiency program could lead to a reduction in total household emissions of 0.45 MtCO2e per year. As the program is evenly spread across the 15-year period, emissions reduction increases by 0.03 MtCO2e per year.

Overall, with the energy efficiency program and the redistribution of household spending, we estimate a net reduction in household emissions between 2023 and 2050 of 8.7 MtCO2e. Although increased household consumption of other goods and services leads to a 0.28 MtCO2e increase in emissions over the 27-year period, this is overshadowed by a 9 MtCO2e reduction associated with the household energy efficiency programs. These results indicate a "double-dividend" effect: increased economic output coupled with a reduction in emissions.

Figure 5. Sensitivity analysis on level of government support for insulation programme



Source: Author's calculations

4.2. Scenario Two – Extended Energy Efficiency Programme

This Section presents the results of the Scenario outlined in Section 3.2, relating to the economic impact of an energy efficiency upgrade programme based on data from the Northern Ireland Housing Condition Survey and publicly available cost data from the Energy Saving Trust. As with the previous Scenario One, we first assess a scenario where the total value of the upgrades is spent in the Northern Ireland economy but the source of the funding is not considered. We then consider a scenario where all of the upgrades are driven and paid for by Households, who also benefit from the potential reduction in energy bills after the upgrades have been performed. Finally, a sensitivity analysis is performed to show the potential impact of varying levels of household and government funding for the programme.

4.2.1. Scenario Two (a) – Gross impact of demand shock only

The demand shock to the economy of £2.8billion was distributed across the Construction and Plastics & Non-Metallic Minerals sectors to account for both the installation and manufacturing costs of insulation and double-glazing. The cost was distributed across the 15-year timeframe of the proposed upgrades for a total of £190million per annum. Table 5 highlights the calculated results of some key metrics for various years. In absolute terms, across the 15 years there is a cumulative increase in GVA of £1.39billion stimulated by the investment in the economy. For employment, 10,310 person-years of employment are supported. These values increase to £1.65billion and 11,890 person-years respectively to the end of the scenario in 2050. The investment in the energy efficiency upgrades outlined in this scenario stimulate economic activity, which is evident across the metrics shown in Table 5. The employment supported by the increased investment in turn supports an increase in household consumption, as the increased wages received by households are spent in the economy.

Table 5. Key results throughout period of investment, % change from business-as-usual

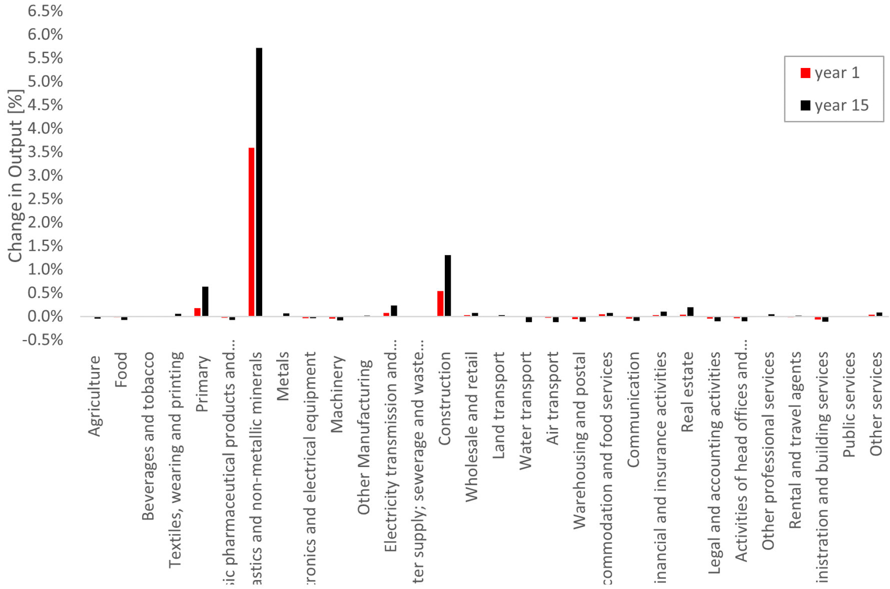
	2023	2027	2037	2038
Gross Value Added	0.03%	0.12%	0.17%	0.11%
Employment	0.05%	0.08%	0.12%	0.04%
Real wage	0.15%	0.23%	0.28%	0.10%
Household Consumption	0.23%	0.26%	0.29%	0.05%
Investment (£m)	0.51%	0.34%	0.27%	-0.18%
Consumer price index (CPI)	0.14%	0.14%	0.13%	-0.02%

Source: Author's calculation

Considering individual sectors, the final year of the investment (2037) sees the largest impact in output for both the construction and manufacturing of the energy efficiency measures – with 1.31% and 5.72% respectively. This is shown in Figure 6 along with the change in output for the remaining sectors in the first and last years of investment. The sector that experiences the largest change outwith those receiving direct investment is the Primary sector, which sees a 0.63% increase in 2037. The Primary sector is closely linked to the industries which received investment in our simulation, particularly as a key input to the plastics and non-metallic minerals sector. As discussed in the previous section, not all sectors see an increase in their output despite the economy as a whole experiencing an uplift.

Whilst this scenario has been considered as an alternate to the scheme described in Sections 3.1 and 4.1, a direct comparison of the results in Table 5 and Figure 6 with the relevant data in Scenario One is not advisable as Scenario One featured an administration fee to account for the management of the funding for the scheme. A likely funding mechanism for Scenario Two has not been predicted, and so it was assumed that all upgrades would be paid for by households themselves – and as such no administration fee was required.

Figure 6. Change in output for each sector, start and end year of Scenario Two (a)



Source: Author's calculations

4.2.2. Scenario Two (b) – Gross impact with Household spending

As with Scenario One, the impact of household spending on efficiency upgrades and household savings on energy bills were considered. Similarly to the discussion in in Section 4.1.3., the simulation was run until 2050 to align with net zero goals. As such, there is a period where the group of households in Northern Ireland are both paying for upgrades and beginning to reap the benefits in energy savings, and there is then a period where the payments are complete but the savings persist.

From our simulation we estimate that by 2050 there will be an increase in GVA of £1.56billion and in employment of 11,320 person-years, when accounting for both household spending on upgrades and the re-spend of the associated energy savings. This is a slight reduction in both metrics of about 5% from Scenario 2(a), when no source for the funding of the energy efficiency measures was considered.

We additionally considered the emissions impact of this scenario, as described in Section 4.1.4. Overall, with the energy efficiency program and the redistribution of household spending, we estimate a net reduction in household emissions between 2023 and 2050 of 8.4MtCO¬2e.

4.2.3. Scenario Two (c) – Impact of Government and Household spend

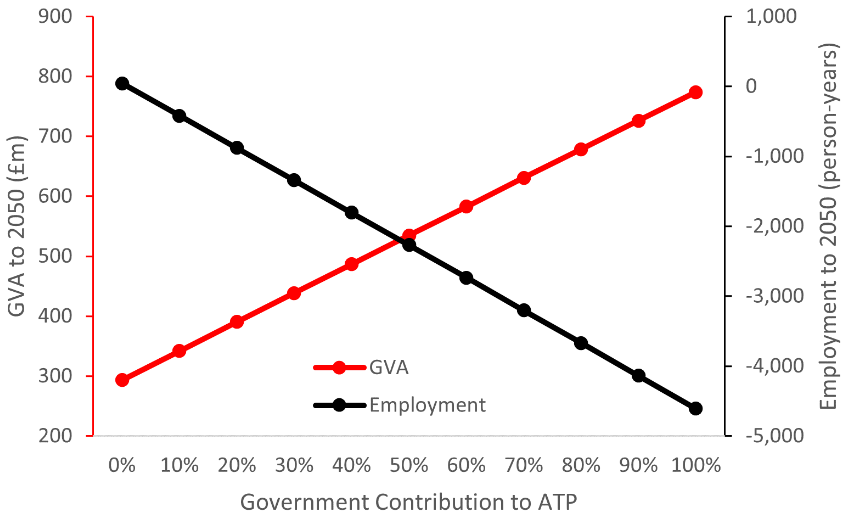
As mentioned previously, no funding mechanism was proposed for this scheme and it was assumed that households would entirely fund the necessary upgrades themselves. For comparison with Scenario One, we carried out a sensitivity analysis to assess the possible impacts of including different shares of government funding for this scheme. We assumed a 20% funding from government for fuel-poor households in all cases, with the remainder of the funding for able-to-pay households split between government and households in steps from 0 – 100%. Of the total £2.84billion investment, this meant £568million was government funded for fuel-poor households, with £2.27billion remaining to be funded.

The results of this sensitivity analysis are displayed in Figure 7, with more detail on the values provided in the Appendix in Section A.3.2. As can be seen from the graph, 10% to 100% of government funding result in a negative impact on employment to 2050 – with higher negative results as the share of government funding increases. This is representative of government funding in the model being sourced from existing government spend, assuming that the total spend has to remain balanced.

Sourcing funds for energy efficiency upgrades under this scenario then means that, in the absence of additional funds being sourced elsewhere, government spend in other sectors must decrease, and this is primarily achieved by less funding for public services. As the public services sector is labour-intensive, this results in a negative impact to employment which is not cancelled out by increasing investment elsewhere in the economy.

In all cases modelled in the sensitivity analysis, an increase in GVA is seen to 2050. However, this is significantly lower than the amounts seen in the analysis of the base insulation retrofit in Section 4.1.4, despite there being a much larger investment into the economy in this extended energy efficiency programme. However, this larger investment requires government or households to reduce their spend on other products to a much higher degree. The results of this are that even beyond the end of the 15-year investment period, when there are savings on energy bills but government and household spend return to BAU levels, GVA and employment do not recover to higher levels due to the legacy effects.

Figure 7. Sensitivity analysis on level of government support for extended energy efficiency programme



Source: Author's calculation

4.3. Scenario Three – Economic Impact of Heat Pump Programme

This Section presents the results of the Scenario outlined in Section 3.3, relating to the economic impact of a heat pump installation programme in Northern Ireland. As with previous scenarios, we first assess the case where no funding is considered, only the change in demand due to the investment. We then consider a scenario where the upgrades are partially funded by a government scheme, scaled by the provision available through the England and Wales Boiler Upgrade Scheme.

4.3.1. Scenario Three (a) – Demand impact of heat pumps

Six heat pump pathways were simulated and, as with the household insulation upgrades, the dynamic impacts of each pathway will be similar with the main difference in the scale of impacts. Table 6 outlines yearly impacts overtime for the 6th carbon budget pathway with optimistic cost reductions.

Table 6. Key results throughout period of investment, % change from business-as-usual

	2023	2027	2037	2038
Gross Value Added	0.04%	0.15%	0.10%	0.04%
Employment	0.07%	0.12%	0.06%	0.02%
Real wage	0.20%	0.33%	0.16%	0.04%
Household consumption	0.30%	0.37%	0.16%	0.03%
Investment (£m)	0.58%	0.49%	0.11%	-0.02%
Consumer price index (CPI)	0.22%	0.23%	0.06%	-0.01%
Heat pumps installed (per year)	19,541	37,674	29,939	2,779
Heat pumps installed (cumulative)	19,541	131,302	634,540	715,823

Source: Author's calculation

Similar to the housing simulations without funding assumptions (Scenario 1(a)), the installation of heat pumps in Northern Ireland stimulates economic activity. Investing in heat pumps increases both Gross Value Added (GVA) and employment throughout all periods up until 2050, the year of the last installation, with the magnitude of impacts corresponding to the number of installations in a given year. For instance, in 2023, with 19,541 heat pumps installed, there is a 0.04% increase in GVA, compared to a 0.15% increase in 2027 when 37,674 heat pumps are installed. The increase in employment also boosts household consumption since there are more people employed in Northern Ireland, resulting in higher disposable income spent on businesses throughout the country. This leads to a 0.37% increase in household consumption in 2027. Additionally, there is an overall increase in investment in physical capital (machinery, etc.) used in the production of goods and services. Although this investment is positive for most time periods, it turns negative in 2050. This shift is driven by the fact that between 2023 and 2050, there has been an increase in physical capital. As investment begins to decline (due to all heat pumps being installed), the depreciation rate of the accumulated capital stock surpasses the investment, resulting in an overall negative value.

From Table 6, investment in heat pumps does drive up prices as in general we see an increase in consumer price index over most of the time-periods, driven by a reduced supply of goods and services pushing up production costs. This does not have impact on aggregate exports as these are positive, but on they will have sectoral impacts and crowding-out effects. Figure 8 outlines the sectoral employment results for the 6th carbon budget optimistic pricing pathway in 2027.

Figure 8. Change in sectoral output across 30 sectors for 6th carbon budget with optimistic reduction scenario in 2027[14]

Source: Author's calculations

By far, the two industries experiencing the largest change in economic output due to the installation of heat pumps are construction and other manufacturing, with increases of 1.26%

14 'Other Manufacturing' sector, with 15.5% change from BAU, has been omitted due to it distorting the graph.

and 15.50% respectively compared with the BAU. This outcome is expected, as these industries are directly linked to heat pump installation and are where the investment is introduced into the CGE model. Additionally, some industries showing increased economic output include metal manufacturing (0.06%) and plastics & non-metallic minerals (0.12%). These sectors are closely tied to construction and other manufacturing, so increased investment in these areas indirectly impacts metal manufacturing and plastics & non-metallic minerals production. There is also a 0.04% increase in wholesale and retail and a 0.08% increase in accommodation and food services. These sectors are mainly linked to increased household activity driven by overall employment growth, rather than directly through the heat pump supply chain.

As previously outlined, it is not a win-win situation for the entire economy. Figure 8 illustrates that many industries actually experience a decrease in economic output. This is primarily driven by the increase in production costs across Northern Ireland, making local goods and services less competitive globally, thereby reducing the value of exports. This decrease in export value often outweighs the increase in local consumption resulting from higher household disposable income. However, across all simulations, we find aggregate impacts on GVA and employment, as outlined in Table 7.

Table 7. Key results for heat pump scenarios

	GVA [£m]	Employment [person years]	Emissions [MtCO2e]
6th Carbon Budget optimistic	1,500	11,420	-17.20
6th Carbon Budget pessimistic	2,100	15,850	-17.00
UK proportion optimistic	660	5,290	-7.50
UK proportion pessimistic	930	7,300	-7.50
UK proportion Net Zero optimistic	1,400	11,370	-15.90
UK proportion Net Zero pessimistic	1,810	14,410	-15.70

Source: Author's calculation

Across all pathways and cost scenarios, there is a substantial increase in economic activity, with Gross Value Added (GVA) increases ranging from £660million to £2.1billion and employment from 5,290 person-years to 15,850 person-years. Interestingly, the two net zero simulations (carbon budget and UK proportion of Net Zero) exhibit larger economic impacts than the current pathway of UK proportion. This outcome is expected, as these net zero targets are based on environmental goals, which may require higher levels of investment from an economic standpoint. Notably, in the higher cost scenarios (pessimistic), the economic impacts are actually larger than in the higher cost reduction (optimistic scenarios). This discrepancy is driven by the increased investment needed to install all the required heat pumps.

However, it is important to note that this analysis focuses solely on the gross impacts of heat pump installation. In reality, similar to other household upgrades, funding for these initiatives will need to be addressed, which we explore in subsequent sections.

In addition to the economic impacts, Table 7 also reports on the environmental benefits associated with the heat pump rollout. Across all simulations, there is a significant net reduction in emissions ranging from 7.5 to 17.2 MtCO2e over the period from 2023 to 2050. As expected, the two scenarios modelling net zero aspirations (6th Carbon Budget and UK proportion net zero) yield larger reductions, as more heat pumps are installed to meet these ambitious targets.

4.3.2. Scenario Three (b) – Impact of heat pumps with Government Spend

The results of the scenario where the widespread installation of heat pumps in Northern Ireland is partially funded by government are shown in Table 8 for the investment period of 2023 – 2050.

In comparison with Table 7, when no funding source was considered, the GVA and employment generated over the timeframe is reduced – albeit by a small amount. In percentage terms the greatest reduction is 1.5%, seen in the employment numbers for the optimistic case of proportioning the UK Heat Pump Investment Roadmap to Northern Ireland population. These reductions are to be expected, as reallocating government funding from other sectors to fund heat pump installation causes a knock-on reduction to sectors such as public services.

Table 8. Key results for heat pump scenarios with Government spend

	GVA [£m]	Employment [person years]
6th Carbon Budget optimistic	1,500	11,350
6th Carbon Budget pessimistic	2,100	15,770
UK proportion optimistic	660	5,290
UK proportion pessimistic	930	7,230
UK proportion Net Zero optimistic	1,400	11,300
UK proportion Net Zero pessimistic	1,810	14,330

Source: Author's calculation

4.4. Scenario Four – Impact of Combined Energy Efficiency Programme

This section presents the results of a combined scenario where both insulation retrofitting activities and heat pump installation are carried out. The results for a series of key metrics over the timeframe of 2023 – 2050 are provided in Table 9.

Table 9. Key results throughout period of investment, % change from business-as-usual

	2023	2027	2042	2050
Gross Value Added	0.07%	0.27%	0.15%	0.04%
Employment	0.13%	0.20%	0.07%	0.02%
Real wage	0.35%	0.56%	0.20%	0.05%
Household consumption	0.53%	0.63%	0.18%	0.04%
Investment (£m)	1.10%	0.84%	0.04%	-0.03%
Consumer price index (CPI)	0.36%	0.37%	0.04%	-0.01%
Heat pumps installed (per year)	19,541	37,674	29,939	2,779
Heat pumps installed (cumulative)	19,541	131,302	634,540	715,823

Source: Author's calculation

These results show that, whilst not accounting for any funding sources, an increase in both GVA and employment is seen across the investment period. Increases are seen in each of the other metrics throughout, with only investment and CPI showing a negative impact in year 2050. As discussed in previous sections, this is due to depreciation of capital stock invested in the years to date and the wind-down of new investment as the scheme comes to a close.

The cumulative impacts of carrying out both insulation retrofit and heat pumps are not the same as simply adding the impacts from each scenario together. There are interactions between sectors which are captured when the combined scenario is modelled, resulting in differing results. This is shown in Table 10 for GVA and employment over the 15-year investment of the insulation retrofit.

Table 10. Cost of heat pump installation in years 2026 – 2028 for each pathway

		2023	2027	2037
GVA (£m)	Extended energy efficiency	40	293	1,142
	Heat pumps 6th CB optimistic	16	214	788
	Combined scenario	***29***	***389***	***1,638***
Employment (person-years)	Extended energy efficiency	428	2,799	10,306
	Heat pumps 6th CB optimistic	459	2,983	7,884
	Combined scenario	***804***	***5,231***	***16,189***

Source: Author's calculation

The results in Table 10 show that, for both GVA and employment, there is a reduced impact with the combined scenario compared with the summation of the individual impacts. In the insulation scenario, only the construction and plastics & non-metallic minerals sectors receive investment – while in the heat pump scenario the investment is into construction and other manufacturing. When the investment is combined in this scenario, interactions between the three sectors are different from the individual cases and result in the variation seen here.

Potential government funding was also modelled, using the same possible funding scheme for heat pumps as discussed in Scenario 3 and a 20% funding of the insulation scheme for fuel-poor households. The results of this are shown in Table 11, which can be compared with Table 8 in Section 4.3.2 for heat pumps only. As would be expected, the GVA and employment stimulated by the combined programme is higher than that for heat pumps only – reflecting the larger investment that is being made into the economy. Considering six possible pathways for heat pump installation, the GVA impact varies from £1.77billion to £3.19billion and employment from 11,760 to 22,180 person-years.

Table 11. Cost of heat pump installation in years 2026 – 2028 for each pathway

	GVA [£m]	Employment [person years]
6th Carbon Budget optimistic	2,600	17,820
6th Carbon Budget pessimistic	3,190	22,180
UK proportion optimistic	1,770	11,760
UK proportion pessimistic	2,040	13,750
UK proportion Net Zero optimistic	2,500	17,810
UK proportion Net Zero pessimistic	2,910	20,800

Source: Author's calculation

5. Conclusion

Northern Ireland is committed to reaching net zero by 2050 with a key principle of reaching this targeting being “do more with less”. Important for this principle is investment in improving the energy efficiency in households which accounted for 12% of emissions in 2021. These efficiency upgrades will lead to a reduction in heat demand thus a reduction in emissions in the residential sector, also with less spending on heating households will a higher level of disposable of income which will be spend throughout the economy.

In this paper we employ an CGE framework to investigate the economic and environmental impacts in Northern Ireland related to the implementation of energy efficiency programmes. Given there are many options and there is currently no defined path from programs we model a range of options, informed by stakeholder discussions and publicly available information. There are three main scenarios modelled: fabric first; housing upgrades based on the energy saving trust and heat pumps along with different funding mechanisms and increase in household income. Summary results are found in Table 12.

Table 12. Summary results for all scenarios and simulations (between 2023-2050)

	GVA (£m)[15]	Employment (person years)	Emissions (MtCO2e)
Scenario 1: Insulation retrofit scheme			
Gross impact of demand shock only (1a)	730	3,940	-8.80
Gross impact with reduction in government spending(1b)	420	30	-8.80
Gross impacts with household spending (1c)	1,330	7,470	-8.80
Combination (1d)	1,020	3,560	-8.70
Scenario 2: Extended energy efficiency programme			
Gross impact of demand shock only (2a)	1,650	11,890	-8.40
Gross impacts with household spending (2b)	1,560	11,320	-8.40
Scenario 3: Heat pump programme			
6th Carbon Budget optimistic	1,500	11,420	-17.20
6th Carbon Budget pessimistic	2,100	15,850	-17.00
UK proportion optimistic	660	5,290	-7.50
UK proportion pessimistic	990	7,300	-7.50
UK proportion Net Zero optimistic	1,400	11,370	-15.90
UK proportion Net Zero pessimistic	1,810	14,410	-15.70
Scenario 4: Combined retrofit and heat pump programme			
6th Carbon Budget optimistic	2,600	17,820	-25.6
6th Carbon Budget pessimistic	3,190	22,180	-25.4
UK proportion optimistic	1,770	11,760	-15.9
UK proportion pessimistic	2,040	13,750	-15.9
UK proportion Net Zero optimistic	2,500	17,810	-24.3
UK proportion Net Zero pessimistic	2,910	20,800	-24.3

Source: Author's calculation

15 In 2024 prices.

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Appendix

Table A.1. Sector description

	Sector Description
S1	Agriculture
S2	Food
S3	Beverages and tobacco
S4	Textiles, wearing and printing
S5	Primary
S6	Basic pharmaceutical products and pharmaceutical preparations
S7	Plastics and non-metallic minerals
S8	Metals
S9	Electronics and electrical equipment
S10	Machinery
S11	Other Manufacturing
S12	Electricity transmission & distribution, gas distribution, steam & air conditioning distribution & supply
S13	Water supply; sewerage and waste management
S14	Construction
S15	Wholesale and retail
S16	Land transport
S17	Water transport
S18	Air transport
S19	Warehousing and postal
S20	Accommodation and food services
S21	Communication
S22	Financial and insurance activities
S23	Real estate
S24	Legal and accounting activities
S25	Activities of head offices and management consultancy
S26	Other professional services
S27	Rental and travel agents
S28	Administration and building services
S29	Public services
S30	Other services

Table A.2. Glossary

Gross Value Added (GVA) – the percentage difference, compared with BAU on the values of goods and services produced in Northern Ireland

Household Consumption – the percentage change, compared with BAU, in the aggregate consumption of goods and services from households, this includes domestic production and imports.

Investment – the percentage difference, compared with BAU in the production of physical capital, the tangible man-made goods such as machinery, which is used are the production of goods and services.

Real wage – the percentage difference, compared with BAU in the average gross wage rate across Northern Ireland in real terms.

Consumer price index (CPI)– the percentage difference, compared with BAU the consumer price index.

Employment – the percentage difference, compared with BAU, in the number of people in employment in full-time equivalent.

A.3 Sensitivity Analysis

This section presents the results of the sensitivity analysis carried out on the scale of government funding for the two energy efficiency programmes outlined in Sections 3.1 and 3.2, whose results were discussed in Sections 4.1 and 4.2 respectively.

A.3.1 Sensitivity analysis on insulation retrofit programme

The outcome of varying the level of funding from government and households for the insulation retrofitting programme with results in Section 4.1 are shown in Table A.3. This programme represents a total £1.11billion investment, with £208million earmarked as government funding for fuel poor households; £73million as an administration cost for facilitating the programme (also government funded); and a remaining £832million which was to be split between government and households.

These results show that in the 15-year period of investment of the insulation programme, while there is a positive impact on GVA across all shares, higher levels of government investment lead to a decrease in employment numbers as compared to the business-as-usual (BAU) case. As discussed in previous sections this is due to the relative labour-intensity of the public services sector – which is the most impacted by government funds being reallocated to fund insulation upgrades.

Looking at the economic impacts out to 2050, all shares of government and household funding result in positive change for both GVA and employment. This is driven by the savings made by households on energy bills which are re-spent into the economy within the model.

Table A.3. Sensitivity analysis results for insulation retrofit programme

Government ATP Contribution	Household ATP Contribution	GVA over 15 years (£m)	Employment over 15 years (person-years)	GVA to 2050 (£m)	Employment to 2050 (person-years)
0%	100%	272	858	958	4,533
10%	90%	276	616	976	4,366
20%	80%	280	373	994	4,200
30%	70%	283	131	1,012	4,033
40%	60%	287	-112	1,030	3,866
50%	50%	291	-355	1,048	3,699
60%	40%	294	-598	1,066	3,531
70%	30%	298	-841	1,083	3,364
80%	20%	302	-1,084	1,101	3,197
90%	10%	305	-1,327	1,119	3,029
100%	0%	309	-1,570	1,137	2,861

Source: Author's calculation

A.3.2 Sensitivity analysis on extended energy efficiency programme

The outcome of varying the level of funding from government and households for the extended energy efficiency programme with results in Section 4.2 are shown in Table A.4. This programme represents a total £2.83 billion investment, more than twice the level modelled for the initial insulation retrofit programme. In order to make comparison between the two schemes, it was assumed that government would again fully fund 20% of the total investment towards upgrades for fuel poor households, totalling £568million for this scheme. This leaves £2.27billion remaining, which was split between government and households.

The results in the table show that over the 15-year investment period of the extended energy efficiency programme, there is a negative impact on both GVA and employment regardless of the government to household split in funding. The £2.27billion investment required is a considerable proportion of both government and household total spend. Reallocating funds to this programme causes a significant reduction in spend on other aspects of the economy, resulting in the decreases seen in the table.

Considering the longer-term outlook to 2050, GVA recovers after the investment period and experiences a boost from BAU for each case. However, employment remains negative in all but the 100% household funding case.

Table A.4. Sensitivity analysis results for extended energy efficiency programme

Government ATP Contribution	Household ATP Contribution	GVA over 15 years (£m)	Employment over 15 years (person-years)	GVA to 2050 (£m)	Employment to 2050 (person-years)
0%	100%	-390	-3,903	293	43
10%	90%	-380	-4,571	342	-418
20%	80%	-371	-5,239	390	-880
30%	70%	-361	-5,908	438	-1,342
40%	60%	-352	-6,578	487	-1,806
50%	50%	-342	-7,248	535	-2,270
60%	40%	-333	-7,919	583	-2,736
70%	30%	-324	-8,591	631	-3,202
80%	20%	-314	-9,263	678	-3,669
90%	10%	-305	-9,936	726	-4,138
100%	0%	-296	-10,610	774	-4,607

Source: Author's calculation

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